

# **A Rooftop Liquid-Desiccant Air Conditioner**

**Mr. William C. Griffiths  
Principal Investigator  
Kathabar, Inc.**

**Dr. Andrew Lowenstein  
AIL Research, Inc.**

**IES Peer Review  
Nashville, TN  
May 1, 2002**

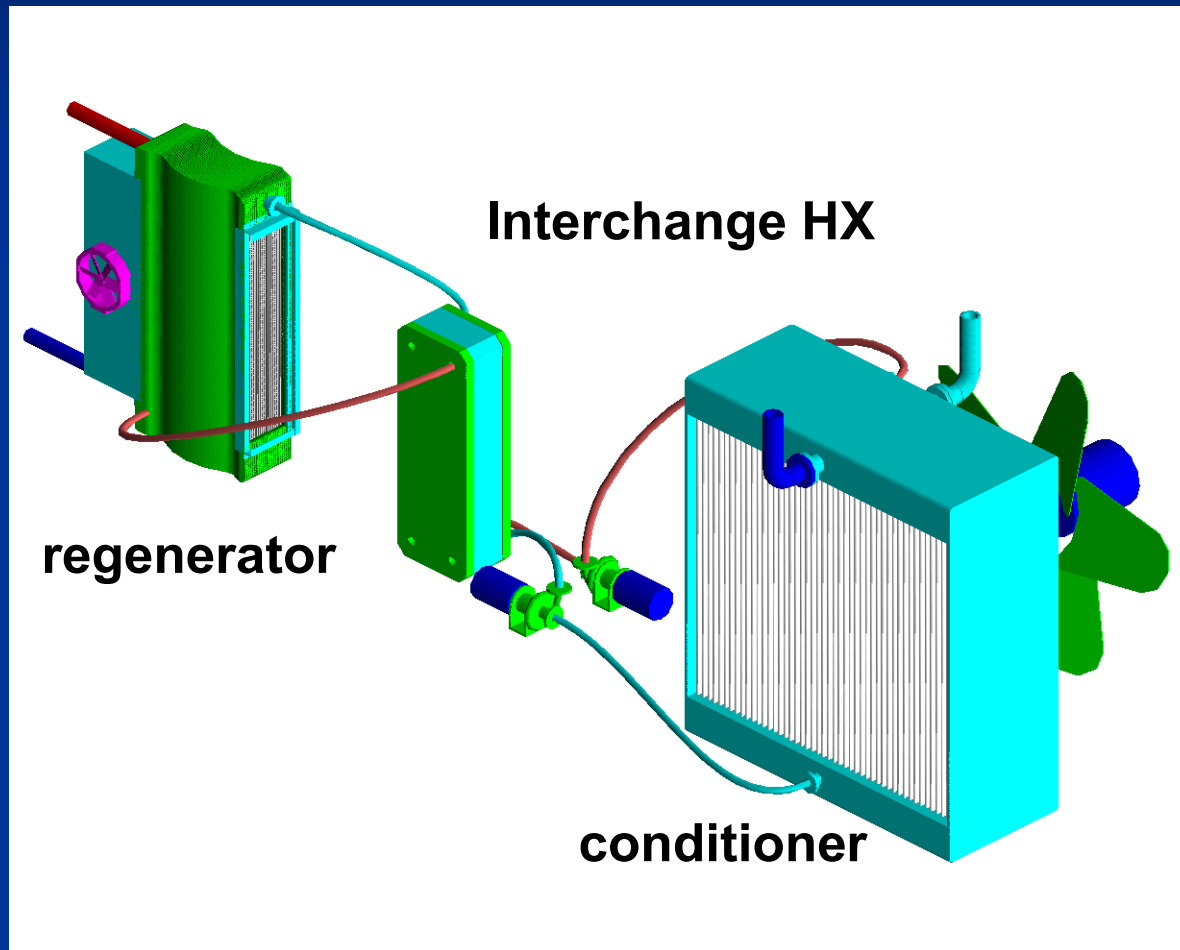
# Overview

- Develop a competitive thermally activated packaged rooftop air conditioner that uses low-flow liquid-desiccant technology
- Physical and functional characteristics close to those of conventional DX rooftop air conditioner
- Gas-fired cooling system that could be adapted to other thermal sources
- Identify promising early markets
- Laboratory demonstration that attracts HVAC manufacturer for Phase II

# Project Team and Partnerships

- Kathabar, Inc.
  - Leading manufacturer of liquid desiccant systems
  - First commercial sale of LiCl system in 1935
  - Unique FRP and sheet metal capability
  - Headquarters in Somerset, NJ
  - 55,000 s.f. manufacturing plant in Elizabethtown, NC
- Mr. William Griffiths, Chief Engineer, Principal Investigator
- AIL Research, Inc.
  - Developer of low-flow liquid-desiccant technology
  - Advanced conditioners and regenerators now ready
- Dr. Andrew Lowenstein, lead AILR engineer

# Generic Liquid-Desiccant AC



# Why Pursue Liquid Desiccants?

- *Heat and mass transfer in a single component*
  - low pressure drops
  - low surface area
  - high “specific” cooling
  - Relatively small size
- *Can use interchange HX*
  - improves efficiency
  - reduces heat “dump back”
- High efficiency options for regeneration
  - VCD regenerator can have COP over 2.0
- Low temperature regeneration also possible
  - 0.6 COP at 160 F
- Potentially low first cost and operating costs

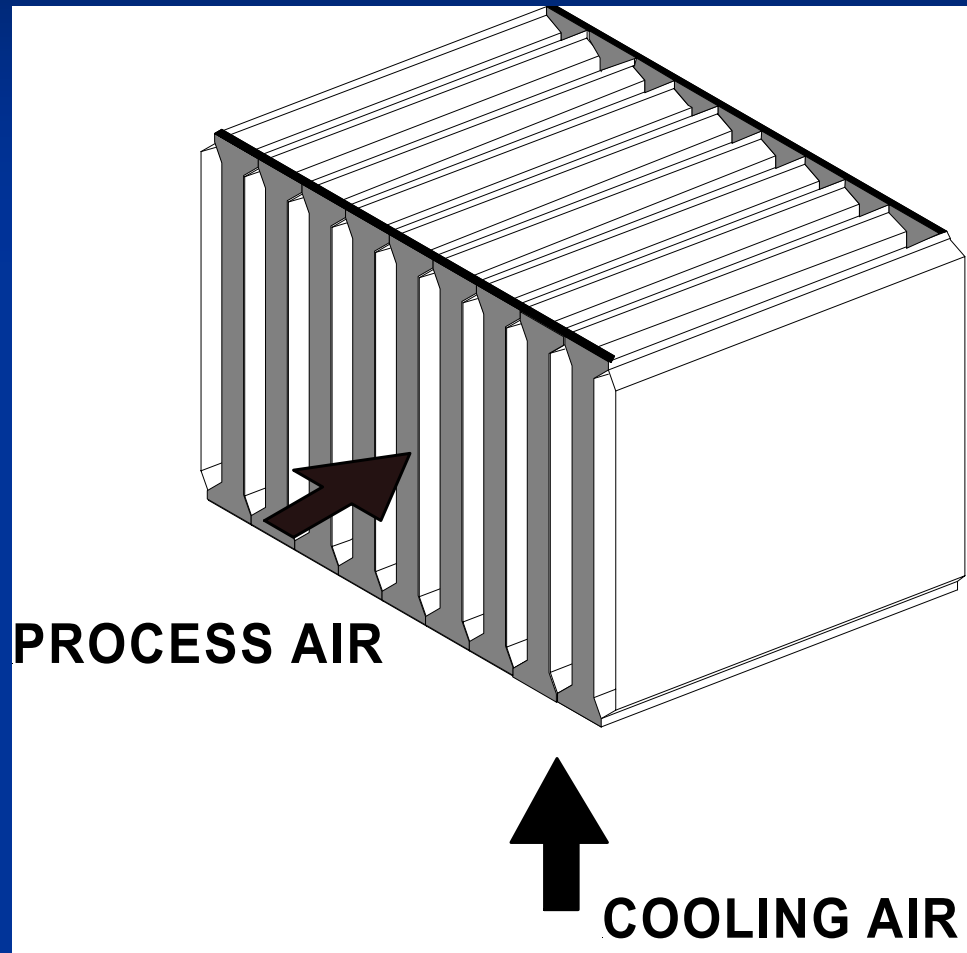
# Tasks

- Identify early markets for rooftop LD air conditioner
- Optimize design of LD air conditioner
- Develop test methods and rating procedures
- Fabricate prototype
- Test prototype in laboratory

# Accomplishments

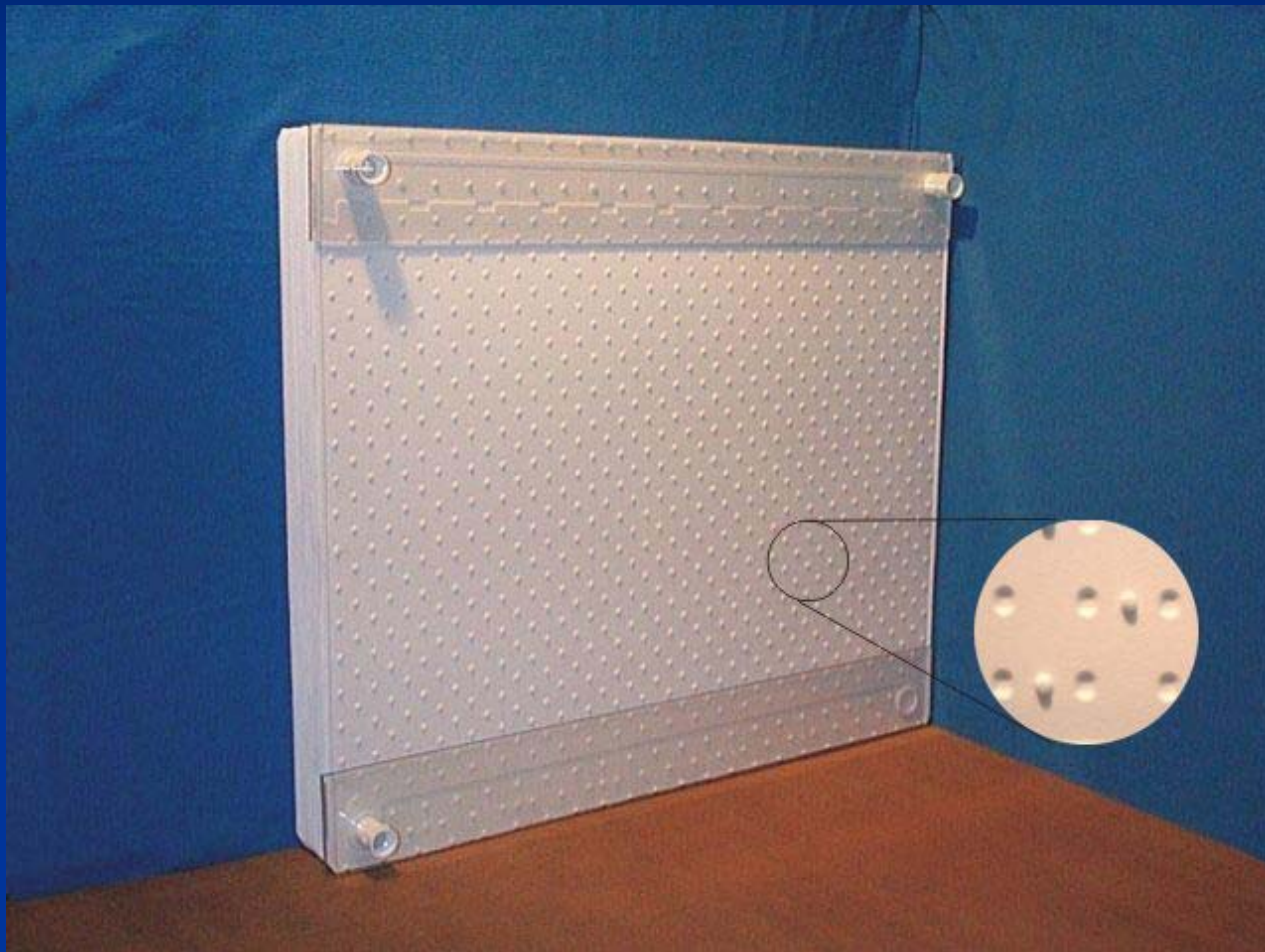
- 15-ton target capacity
  - \$160,000,000/year sales for 11 to 15-ton packaged ACs
  - 5 to 11-ton market is larger but it will be more difficult to compete with smaller low-cost DX systems
- Target markets that demand superior latent performance
- Preliminary designs completed for three configurations
  - Evaporatively cooled conditioner
  - Water-cooled conditioner with open cooling tower
  - Water-cooled conditioner with closed fluid cooler
- All configurations use high-efficiency 1½-effect regenerator
- Comparable seasonal performance for three designs

# Evaporatively Cooled Conditioner

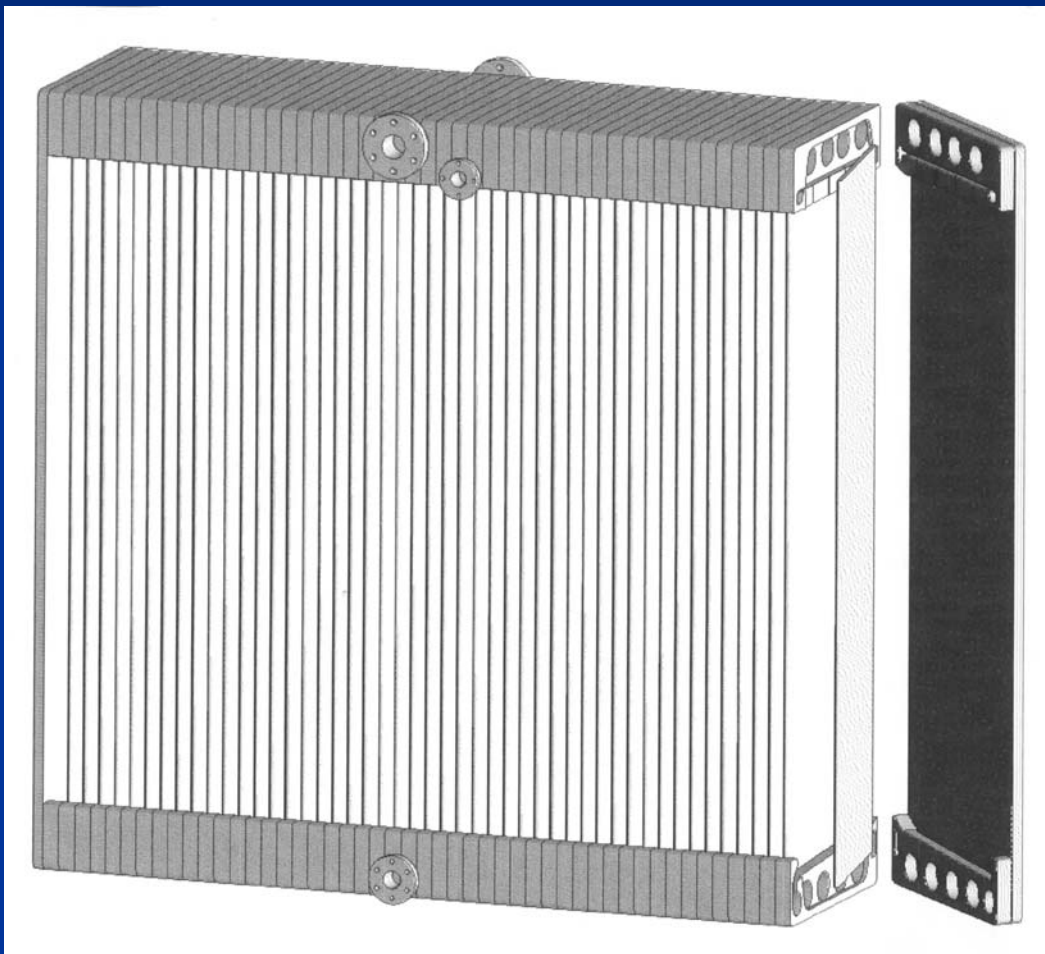




# Evaporatively-Cooled Model



# Water-Cooled Conditioner



# Assembly of 6,000 cfm Conditioner



# 6,000 cfm Conditioner

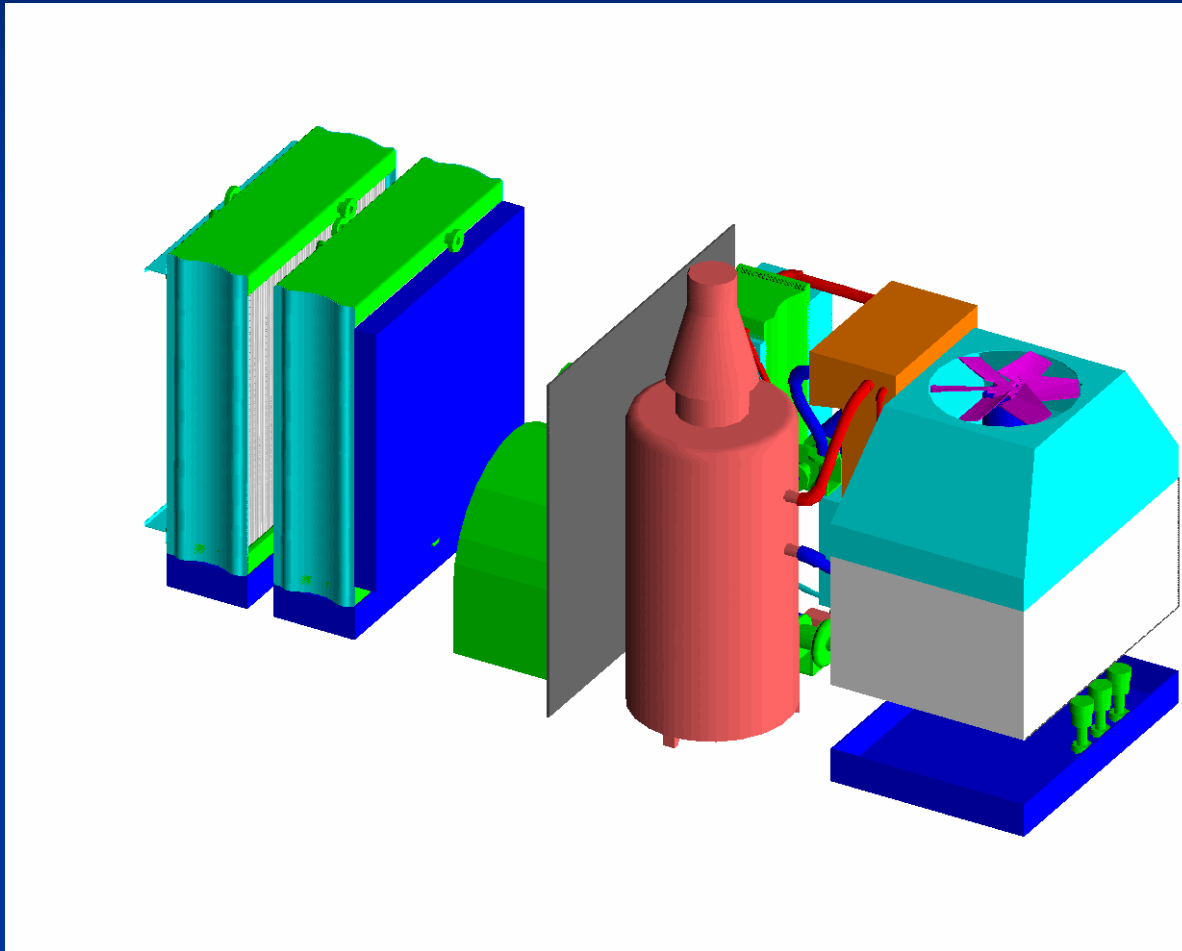




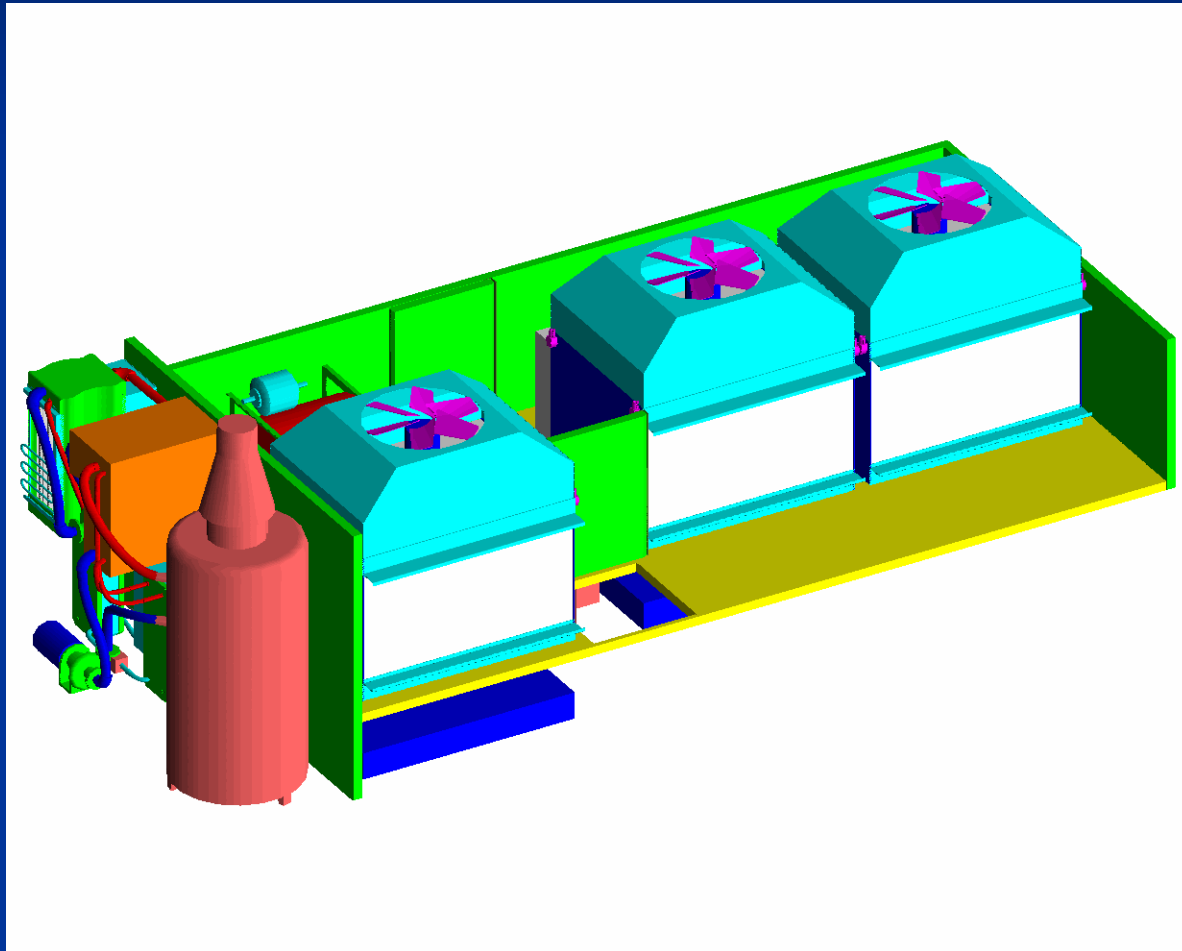
# Water-Cooled versus Evap-Cooled

- Evap-cooled conditioner will have closer approach to wet-bulb temperature
  - Evap-cooled: 338 cfm per ton
  - Water-cooled & CT: 370 cfm per ton
  - Water-cooled & CFC: 383 cfm per ton
- Evap-cooled conditioner will have less material; potentially lower cost
- Water-cooled conditioner ready to operate in field; evap-cooled more than 6-months behind (Phase II DOE SBIR)
- Water-cooled conditioner easier to package as rooftop unit; more compact design

# 15-ton Rooftop AC with Water-Cooled Conditioner



# 15-Ton Rooftop AC with Evap-Cooled Conditioner



# Impact of Advanced LD Technology

## Humidity Control with High Latent Loads

- Conventional DX system with reheat
- Conventional DX system with Air-Air HX
- Evap-cooled liquid-desiccant conditioner
  - Constant desiccant concentration
  - Variable desiccant concentration



# Impact of Advanced LD Technology

## Humidity Control with High Latent Loads

### Assumptions

- School in Houston, TX
- 10,000 cfm (30% nominal) ventilation air
- ventilation for 13 hours per day, weekdays only
- April through October; summer school session
- Humidity loads must be met
- For DX, 4-row evaporator, 275 fpm face velocity
- 80% efficient gas-fired boiler for reheat

# Impact of Advanced LD Technology

	air flow cfm	excess sensible kBtu	compress power kWh	main fan power kWh	7-month demand kW	gas therm	cost dollars
DX with reheat	67,200	759,023	172,809	60,147	1,495	0	31,634
DX with 50% A-A HX	45,150	105,966	132,711	60,168	1,090	1,325	21,087
Evap-Cooled LD, 45% LiCl	41,103	0	0	58,253	329	19,403	17,770
Evap-Cooled, 32% to 45% LiCl	41,103	0	0	58,253	329	17,217	16,459

"A-A HX" -- air-to-air heat exchanger  
 "LD" -- liquid-desiccant conditioner

COE \$0.06 per kWh  
 COG \$0.60 per therm  
 demand \$8.00 per kW

# **Manufacturing Costs**

## **6,000 cfm Rooftop AC**

### **500 units per year**

- |                               |                |
|-------------------------------|----------------|
| ➤ Water-cooled conditioner    | \$3,750        |
| ➤ Scavenging air regenerator  | \$ 275         |
| ➤ High-Temp regenerator stage | \$ 660         |
| ➤ Interchange heat exchanger  | \$ 340         |
| ➤ Cooling tower               | \$ 760         |
| ➤ Fluid heater                | \$1,600        |
| ➤ Partial total               | \$1.23 per cfm |

# Size of Rooftop Air Conditioner

- |                               |                 |
|-------------------------------|-----------------|
| ➤ Conventional 25-ton rooftop | 67 cf/1000 cfm  |
| ➤ Evap-cooled 15-ton rooftop  | 134 cf/1000 cfm |
| ➤ Water-cooled 15-ton rooftop | 70 cf/1000 cfm  |

# Project Milestones

- Select target capacity
  - Completed – November 2001
- Optimize conceptual designs
  - Completed – March 2002
- Select conditioner & prepare product drawings
  - On schedule – August 2002
- Fabrication of prototype
  - On schedule – February 2003
- Laboratory test of prototype
  - On schedule – summer 2003

# Summary

- Low-flow liquid-desiccant conditioner to be tested at Kathabar plant this summer
- Low-flow scavenging-air regenerator to be tested at Kathabar plant this summer
- Evaporatively-cooled conditioner preferred if technology is ready
- 1½-effect regenerator preferred, but first prototype may use only scavenging-air regenerator
- Potentially the lowest cost option for controlling indoor humidity when latent loads are high
- Significant energy savings when coupled to on-site fuel cell or engine-driven generator
  - COP of 1.25 with 320 F heat source
  - COP of 0.60 with 160 F heat source